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मात्राएँ और इकाइयाँ

भाग 9 परमाण्विक एवं नाभिकीय भौतिकी

(पहला पुनरीक्षण)

Indian Standard

QUANTITIES AND UNITS

PART 9 ATOMIC AND NUCLEAR PHYSICS

(First Revision)

UDC 53.081

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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Price Group 8

Basic Standards Sectional Committee, MSD 1

NATIONAL FOREWORD

This Indian Standard (Part 9) (First Revision) which is identical with ISO 31-9 : 1992, issued by the International Organization for Standardization (ISO) was adopted by the Bureau of Indian Standards on the recommendation of the Basic Standards Sectional Committee (MSD 1) and approval of the Management and Systems Division Council.

The text of the ISO Standard has been approved as suitable for publication as Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

> Comma (,) has been used as a decimal marker while in Indian Standards the current practice is to use a point (.) as the decimal marker.
>
> Wherever the words 'International Standard' appear, referring to this standard, they should be read as 'Indian Standard'.

This standard was first published in 1983. In this revision, following changes have been made:

a) The decision by the International Committee for Weights and Measures (CIPM) in 1980 concerning the status of supplementary units has been incorporated;

b) One new item 'Volumic activity' has been added;

c) Six new chemical elements given at atomic numbers 104 to 109 have been added in Annex A (Normative); and

d) Units in use temporarily have been transferred to the 'Conversion factors and remarks' column.

ADDITIONAL INFORMATION

IS 1890/ISO 31 consists of the following parts, under the general title 'Quantities and Units':

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
ISO 31-0 : 1992	IS 1890 (Part 0) : 1995 Quantities and units : Part 0 General principles (*first revision*)	Identical
ISO 31-1 : 1992	IS 1890 (Part 1) : 1995 Quantities and units : Part 1 Space and time (*third revision*)	Identical
ISO 31-2 : 1992	IS 1890 (Part 2) : 1995 Quantities and units : Part 2 Periodic and related phenomena (*second revision*)	Identical
ISO 31-3 : 1992	IS 1890 (Part 3) : 1995 Quantities and units : part 3 Mechanics (*second revision*)	Identical
ISO 31-4 : 1992	IS 1890 (Part 4) : 1982* Quantities, units and symbols : Part 4 Heat (*first revision*)	Technically Equivalent

(*Continued on third cover*)

Indian Standard
QUANTITIES AND UNITS
PART 9 ATOMIC AND NUCLEAR PHYSICS
(First Revision)

1 Scope

This part of ISO 31 gives names and symbols for quantities and units of atomic and nuclear physics. Where appropriate, conversion factors are also given.

2 Names and symbols

The names and symbols for quantities and units of atomic and nuclear physics are given on the following pages.

ATOMIC AND NUCLEAR PHYSICS — Quantities

Item No.	Quantity	Symbol	Definition	Remarks
9-1	proton number, atomic number	Z	Number of protons in an atomic nucleus	A nuclide is a species of atom with specified numbers of protons and neutrons. Nuclides with the same value of Z are called isotopes. The atomic number in the periodic table is equal to the proton number. See also annex B.
9-2	neutron number	N	Number of neutrons in an atomic nucleus	Nuclides with the same value of N are called isotones. $N - Z$ is called the neutron excess number.
9-3	nucleon number, mass number	A	Number of nucleons in an atomic nucleus	$A = Z + N$ Nuclides with the same value of A are called isobars. See also annex B.
9-4.1	mass of atom (of a nuclide X), nuclidic mass	m_a, $m(\mathrm{X})$	Rest mass of a neutral atom in the ground state	For hydrogen ^{1}H, $m(^1\mathrm{H}) = (1{,}673\,534\,0 \pm 0{,}000\,001\,0) \times 10^{-27}$ kg $= (1{,}007\,825\,048 \pm 0{,}000\,000\,012)$ u
9-4.2	unified atomic mass constant	m_u	1/12 of the rest mass of a neutral atom of the nuclide ^{12}C in the ground state	$m_u = (1{,}660\,540\,2 \pm 0{,}000\,001\,0) \times 10^{-27}$ kg [1] $= 1$ u $\frac{m_a}{m_u}$ is called the relative nuclidic mass.

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[1] CODATA Bulletin 63 (1986).

Units — ATOMIC AND NUCLEAR PHYSICS

Item No.	Name of unit	International symbol for unit	Definition	Conversion factors and remarks
9-1.a	one	1		See the introduction, subclause 0.3.2.
9-2.a	one	1		See the introduction, subclause 0.3.2.
9-3.a	one	1		See the introduction, subclause 0.3.2.
9-4.a	kilogram	kg		
9-4.b	unified atomic mass unit	u	1 unified atomic mass unit is equal to 1/12 of the rest mass of a neutral atom of the nuclide ^{12}C in the ground state	1 u = (1,660 540 2 ± 0,000 001 0) × 10^{-27} kg [1]

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[1] CODATA Bulletin 63 (1986).

ATOMIC AND NUCLEAR PHYSICS (*continued*) Quantities

Item No.	Quantity	Symbol	Definition	Remarks
9-5.1	(rest) mass of electron	m_{e}		For a particle with rest mass m, the quantity mc^2 is called its rest energy. m_{e} = (9,109 389 7 ± 0,000 005 4) × 10^{-31} kg = (5,485 799 03 ± 0,000 000 13) × 10^{-4} u 1)
9-5.2	(rest) mass of proton	m_{p}		m_{p} = (1,672 623 1 ± 0,000 001 0) × 10^{-27} kg = (1,007 276 470 ± 0,000 000 012) u 1)
9-5.3	(rest) mass of neutron	m_{n}		m_{n} = (1,674 928 6 ± 0,000 001 0) × 10^{-27} kg = (1,008 664 904 ± 0,000 000 014) u 1)

1) CODATA Bulletin 63 (1986).

9-6	elementary charge	e	Electric charge of a proton	The electric charge of an electron is equal to $-e$. e = (1,602 177 33 ± 0,000 000 49) × 10^{-19} C 1)

1) CODATA Bulletin 63 (1986).

9-7	Planck constant	h	Elementary quantum of action	h = (6,626 075 5 ± 0,000 004 0) × 10^{-34} J · s 1) $\hbar = h/2\pi$ = (1,054 572 66 ± 0,000 000 63) × 10^{-34} J · s 1)

1) CODATA Bulletin 63 (1986).

9-8	Bohr radius	a_0	$a_0 = 4\pi\varepsilon_0\hbar^2/m_{\mathrm{e}}e^2$	a_0 = (5,291 772 49 ± 0,000 000 24) × 10^{-11} m 1)

1) CODATA Bulletin 63 (1986).

9-9	Rydberg constant	R_∞	$R_\infty = \dfrac{e^2}{8\pi\varepsilon_0 a_0 hc}$	R_∞ = (1,097 373 153 4 ± 0,000 000 001 3) × 10^7 m^{-1} 1) For hydrogen ^{1}H, $R_{\mathrm{H}} = R_\infty/(1 + m_{\mathrm{e}}/m_{\mathrm{p}})$ The quantity $R_\infty \cdot hc$ is called the Rydberg energy (Ry).

1) CODATA Bulletin 63 (1986).

Units ATOMIC AND NUCLEAR PHYSICS (*continued*)

Item No.	**Name of unit**	**International symbol for unit**	**Definition**	**Conversion factors and remarks**
9-5.a	kilogram	kg		
9-5.b	unified atomic mass unit	u		1 u = (1,660 540 2 ± 0,000 001 0) × 10^{-27} kg [1]

[1] CODATA Bulletin 63 (1986).

Item No.	**Name of unit**	**International symbol for unit**	**Definition**	**Conversion factors and remarks**
9-6.a	coulomb	C		
9-7.a	joule second	J · s		
9-8.a	metre	m		ångström (Å), 1 Å = 10^{-10} m
9-9.a	reciprocal metre, metre to the power minus one	m^{-1}		

ATOMIC AND NUCLEAR PHYSICS (*continued*) Quantities

Item No.	Quantity	Symbol	Definition	Remarks
9-10	Hartree energy	E_h	$E_h = e^2/4\pi\varepsilon_0 a_0 = 2R_\infty \cdot hc$	$E_h = (4{,}359\ 748\ 2 \pm 0{,}000\ 002\ 6) \times 10^{-18}$ J 1)
1) CODATA Bulletin 63 (1986).				
9-11.1	magnetic moment of particle or nucleus	μ	Expectation value of the component of the electromagnetic moment in the direction of the magnetic field in the quantum state with maximum magnetic quantum number	The energy in a magnetic field with magnetic flux density B, in the quantum state with maximum magnetic quantum number, in a vacuum, is equal to $-\mu B$.
9-11.2	Bohr magneton	μ_B	$\mu_B = e\hbar/2m_e$	$\mu_B = (9{,}274\ 015\ 4 \pm 0{,}000\ 003\ 1) \times 10^{-24}\ \mathrm{A \cdot m^2}$ 1)
9-11.3	nuclear magneton	μ_N	$\mu_N = e\hbar/2m_p = (m_e/m_p)\mu_B$	$\mu_N = (5{,}050\ 786\ 6 \pm 0{,}000\ 001\ 7) \times 10^{-27}\ \mathrm{A \cdot m^2}$ 1)
1) CODATA Bulletin 63 (1986).				
9-12	gyromagnetic coefficient, (gyromagnetic ratio)	γ	$\gamma = \mu/J\hbar$ where J is the angular momentum quantum number	The gyromagnetic coefficient of the proton is indicated by γ_p. $\gamma_p = (2{,}675\ 221\ 28 \pm 0{,}000\ 000\ 81) \times 10^8\ \mathrm{A \cdot m^2/(J \cdot s)}$ 1)
1) CODATA Bulletin 63 (1986).				
9-13.1	g-factor of atom or electron	g	$\gamma = -g\frac{\mu_B}{\hbar} = -g\frac{e}{2m_e}$	These quantities are also called g-values. For a free electron, $g_e = 2{,}002\ 319\ 304\ 386 \pm 0{,}000\ 000\ 000\ 020$
9-13.2	g-factor of nucleus or nuclear particle	g	$\gamma = g\frac{\mu_N}{\hbar} = g\frac{e}{2m_p}$	
9-14.1	Larmor angular frequency	ω_L	$\omega_L = \frac{e}{2m_e}B$	$\nu_L = \omega_L/2\pi$ is called the Larmor frequency.
9-14.2	nuclear precession angular frequency	ω_N	$\omega_N = \gamma B$ where B is the magnetic flux density	

Units ATOMIC AND NUCLEAR PHYSICS (*continued*)

Item No.	Name of unit	International symbol for unit	Definition	Conversion factors and remarks
9-10.a	joule	J		
9-11.a	ampere square metre	$A \cdot m^2$		
9-12.a	ampere square metre per joule second	$A \cdot m^2/(J \cdot s)$		$1\ A \cdot m^2/(J \cdot s) = 1\ A \cdot s/kg = 1\ T^{-1} \cdot s^{-1}$
9-13.a	one	1		See the introduction, subclause 0.3.2.
9-14.a	radian per second	rad/s		See the introduction, subclause 0.3.2.
9-14.b	reciprocal second, second to the power minus one	s^{-1}		

ATOMIC AND NUCLEAR PHYSICS (*continued*) Quantities

Item No.	Quantity	Symbol	Definition	Remarks
9-15	cyclotron angular frequency	ω_c	$\omega_c = \frac{q}{m} B$ where q/m is the charge to mass ratio of the particle and B is the magnetic flux density	$\nu_c = \omega_c/2\pi$ is called the cyclotron frequency.
9-16	nuclear quadrupole moment	Q	Expectation value of the quantity $(1/e) \int \left(3z^2 - r^2\right) \varrho(x, y, z) \, \mathrm{d}V$ in the quantum state with the nuclear spin in the field (z) direction; $\varrho(x, y, z)$ is the nuclear charge density, e is the elementary charge and dV is the volume element dx dy dz	The electric nuclear quadrupole moment is eQ.
9-17	nuclear radius	R	Average radius of volume in which the nuclear matter is included	This quantity is not exactly defined. It is given approximately by $R = r_0 A^{1/3}$ where $r_0 \approx 1{,}2 \times 10^{-15}$ m and A is the nucleon number.
9-18	orbital angular momentum quantum number	l_i, L		l_i refers to a particle i; L is used for the whole system.
9-19	spin angular momentum quantum number	s_i, S		s_i refers to a particle i; S is used for the whole system.
9-20	total angular momentum quantum number	j_i, J		j_i refers to a particle i; J is used for the whole system.
9-21	nuclear spin quantum number	I		In nuclear and particle physics, J is often used.
9-22	hyperfine structure quantum number	F		
9-23	principal quantum number	n		

Units ATOMIC AND NUCLEAR PHYSICS (*continued*)

Item No.	Name of unit	International symbol for unit	Definition	Conversion factors and remarks
9-15.a	radian per second	rad/s		See the introduction, subclause 0.3.2.
9-15.b	reciprocal second, second to the power minus one	s^{-1}		
9-16.a	metre squared	m^2		
9-17.a	metre	m		Quantity 9-17 is usually expressed in femtometres. 1 fm = 10^{-15} m
9-18.a	one	1		See the introduction, subclause 0.3.2.
9-19.a	one	1		See the introduction, subclause 0.3.2.
9-20.a	one	1		See the introduction, subclause 0.3.2.
9-21.a	one	1		See the introduction, subclause 0.3.2.
9-22.a	one	1		See the introduction, subclause 0.3.2.
9-23.a	one	1		See the introduction, subclause 0.3.2.

ATOMIC AND NUCLEAR PHYSICS (*continued*) Quantities

Item No.	Quantity	Symbol	Definition	Remarks
9-24	magnetic quantum number	m_i, M		m_i refers to a particle i; M is used for the whole system. Subscripts L, S, J, etc., as appropriate, may be added to indicate the angular momentum involved.
9-25	fine-structure constant	α	$\alpha = e^2/4\pi\varepsilon_0\hbar c$	$\alpha = (7{,}297\ 353\ 08 \pm 0{,}000\ 000\ 33) \times 10^{-3}$ 1) $1/\alpha = 137{,}035\ 989\ 5 \pm 0{,}000\ 006\ 1$ 1)

1) CODATA Bulletin 63 (1986).

9-26	electron radius	r_e	$r_e = e^2/4\pi\varepsilon_0 m_e c^2$	$r_e = (2{,}817\ 940\ 92 \pm 0{,}000\ 000\ 38) \times 10^{-15}$ m 1)

1) CODATA Bulletin 63 (1986).

9-27	Compton wavelength	λ_C	$\lambda_C = 2\pi\hbar/mc = h/mc$ where m is the rest mass of the particle	For the proton, $\lambda_{C,p} = (1{,}321\ 410\ 02 \pm 0{,}000\ 000\ 12) \times 10^{-15}$ m 1) For the neutron, $\lambda_{C,n} = (1{,}319\ 591\ 10 \pm 0{,}000\ 000\ 12) \times 10^{-15}$ m 1)

1) CODATA Bulletin 63 (1986).

9-28.1	mass excess	Δ	$\Delta = m_a - Am_u$	If the binding energy of the atomic electrons is neglected, Bc^2 is equal to the binding energy of the nucleus.
9-28.2	mass defect	B	$B = Zm(^1\mathrm{H}) + Nm_n - m_a$	
9-29.1	relative mass excess	Δ_r	$\Delta_r = \Delta/m_u$	
9-29.2	relative mass defect	B_r	$B_r = B/m_u$	
9-30.1	packing fraction	f	$f = \Delta_r/A$	
9-30.2	binding fraction	b	$b = B_r/A$	

Units ATOMIC AND NUCLEAR PHYSICS (*continued*)

Item No.	Name of unit	International symbol for unit	Definition	Conversion factors and remarks
9-24.a	one	1		See the introduction, subclause 0.3.2.
9-25.a	one	1		See the introduction, subclause 0.3.2.
9-26.a	metre	m		
9-27.a	metre	m		
9-28.a	kilogram	kg		
9-28.b	unified atomic mass unit	u		1 u = (1,660 540 2 ± 0,000 001 0) × 10^{-27} kg [1] Quantities 9-28.1 and 9-28.2 are usually expressed in unified atomic mass units.
9-29.a	one	1		See the introduction, subclause 0.3.2.
9-30.a	one	1		See the introduction, subclause 0.3.2.

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1) CODATA Bulletin 63 (1986).

ATOMIC AND NUCLEAR PHYSICS (*continued*) Quantities

Item No.	Quantity	Symbol	Definition	Remarks
9-31	mean life	τ	$\tau = \int_0^\infty t \frac{\mathrm{d}N}{\mathrm{d}t}\,\mathrm{d}t \Big/ \int_0^\infty \frac{\mathrm{d}N}{\mathrm{d}t}\,\mathrm{d}t$ where $\frac{\mathrm{d}N}{\mathrm{d}t}\,\mathrm{d}t$ is the number of atoms decaying in the time interval $\mathrm{d}t$	For exponential decay, $N = N_0\,\mathrm{e}^{-\lambda t}$, and $\tau = 1/\lambda$ is the time required for N to decrease from N_0 to N_0/e.
9-32	level width	Γ	$\Gamma = \frac{\hbar}{\tau}$	
9-33	activity	A	Average number of spontaneous nuclear transitions from a particular energy state occurring in an amount of a radionuclide in a small time interval, divided by that interval	$A = -\mathrm{d}N/\mathrm{d}t$ For exponential decay, $A = \lambda/N$, where λ is the decay constant (see 9-36).
9-34	massic activity, specific activity	a	Activity divided by the total mass of the sample	
9-35 (—)	volumic activity, activity concentration	c_A	Activity divided by the total volume of the sample	
9-36 (*9-35.1*)	decay constant, disintegration constant	λ	Probability of decay in a small time interval, divided by that interval. $\mathrm{d}N/\mathrm{d}t = -\lambda N$ where N is the number of radioactive atoms at time t, and $\lambda = 1/\tau$	This quantity is a constant only for exponential decay. $\lambda = \Sigma\lambda_a$, where λ_a denotes the probability of decay to a specified final state and the sum is over all final states.
9-37 (*9-36.1*)	half-life	$T_{1/2}$	Average time required for the decay of one half of the atoms of a sample of a radioactive nuclide	For exponential decay, $T_{1/2} = (\ln 2)/\lambda = \tau \ln 2$
9-38 (*9-37.1*)	alpha disintegration energy	Q_α	Sum of the kinetic energy of the α particle produced in the disintegration process and the recoil energy of the product atom in the reference frame in which the emitting nucleus is at rest before its disintegration	The ground-state alpha disintegration energy, $Q_{\alpha,0}$, also includes the energy of any gamma radiation produced.

Units ATOMIC AND NUCLEAR PHYSICS (*continued*)

Item No.	Name of unit	International symbol for unit	Definition	Conversion factors and remarks
9-31.a	second	s		
9-32.a	joule	J		
9-32.b	electronvolt	eV		1 eV = (1,602 177 33 ± 0,000 000 49) × 10^{-19} J 1)

1) CODATA Bulletin 63 (1986).

9-33.a	becquerel	Bq	1 Bq = 1 s^{-1}	The becquerel is a special name for second to the power minus one, to be used as the SI unit of activity. curie (Ci), 1 Ci = 3,7 × 10^{10} Bq (exactly)
9-34.a	becquerel per kilogram	Bq/kg		
9-35.a	becquerel per cubic metre	Bq/m^3		
9-36.a	reciprocal second, second to the power minus one	s^{-1}		
9-37.a	second	s		
9-38.a	joule	J		
9-38.b	electronvolt	eV		Quantity 9-38 is usually expressed in electronvolts. 1 eV = (1,602 177 33 ± 0,000 000 49) × 10^{-19} J 1)

1) CODATA Bulletin 63 (1986).

ATOMIC AND NUCLEAR PHYSICS (*concluded*) — Quantities

Item No.	Quantity	Symbol	Definition	Remarks
9-39 (*9-38.1*)	maximum beta particle energy	E_β	Maximum energy of the energy spectrum in a beta disintegration process	
9-40 (*9-39.1*)	beta disintegration energy	Q_β	Sum of the maximum beta particle energy E_β and the recoil energy of the atom produced in the reference frame in which the emitting nucleus is at rest before its disintegration	For positron emitters, the energy for the production of an electron pair has to be added to the sum mentioned in the definition. The ground-state beta disintegration energy, $Q_{\beta,0}$, also includes the energy of any gamma radiation produced.
9-41 (*9-40.1*)	internal conversion factor	α	Ratio of the number of internal conversion electrons to the number of gamma quanta emitted by the atom in a given transition	The quantity $\alpha/(\alpha + 1)$ is also used and may be called the internal conversion fraction. Partial conversion factors referring to the various electron shells K, L, ... are indicated by α_K, α_L, ... α_K/α_L is called the K to L internal conversion ratio.

Units — ATOMIC AND NUCLEAR PHYSICS (*concluded*)

Item No.	Name of unit	International symbol for unit	Definition	Conversion factors and remarks
9-39.a	joule	J		
9-39.b	electronvolt	eV		Quantity 9-39 is usually expressed in electronvolts. $1\ \text{eV} = (1{,}602\ 177\ 33 \pm 0{,}000\ 000\ 49) \times 10^{-19}\ \text{J}$ 1)
1) CODATA Bulletin 63 (1986).				
9-40.a	joule	J		
9-40.b	electronvolt	eV		Quantity 9-40 is usually expressed in electronvolts. $1\ \text{eV} = (1{,}602\ 177\ 33 \pm 0{,}000\ 000\ 49) \times 10^{-19}\ \text{J}$ 1)
1) CODATA Bulletin 63 (1986).				
9-41.a	one	1		See the introduction, subclause 0.3.2.

Annex A
(normative)

Names and symbols of the chemical elements[1]

Atomic number	Name	Symbol
1	hydrogen	H
2	helium	He
3	lithium	Li
4	beryllium	Be
5	boron	B
6	carbon	C
7	nitrogen	N
8	oxygen	O
9	fluorine	F
10	neon	Ne
11	sodium, (natrium)	Na
12	magnesium	Mg
13	aluminium	Al
14	silicon	Si
15	phosphorus	P
16	sulfur	S
17	chlorine	Cl
18	argon	Ar
19	potassium, (kalium)	K
20	calcium	Ca
21	scandium	Sc
22	titanium	Ti
23	vanadium	V
24	chromium	Cr
25	manganese	Mn
26	iron, (ferrum)	Fe
27	cobalt	Co
28	nickel	Ni
29	copper, (cuprum)	Cu
30	zinc	Zn
31	gallium	Ga
32	germanium	Ge
33	arsenic	As
34	selenium	Se
35	bromine	Br
36	krypton	Kr
37	rubidium	Rb
38	strontium	Sr
39	yttrium	Y
40	zirconium	Zr
41	niobium	Nb
42	molybdenum	Mo

Atomic number	Name	Symbol
43	technetium	Tc
44	ruthenium	Ru
45	rhodium	Rh
46	palladium	Pd
47	silver, (argentum)	Ag
48	cadmium	Cd
49	indium	In
50	tin, (stannum)	Sn
51	antimony, (stibium)	Sb
52	tellurium	Te
53	iodine	I
54	xenon	Xe
55	caesium	Cs
56	barium	Ba
57	lanthanum	La
58	cerium	Ce
59	praseodymium	Pr
60	neodymium	Nd
61	promethium	Pm
62	samarium	Sm
63	europium	Eu
64	gadolinium	Gd
65	terbium	Tb
66	dysprosium	Dy
67	holmium	Ho
68	erbium	Er
69	thulium	Tm
70	ytterbium	Yb
71	lutetium	Lu
72	hafnium	Hf
73	tantalum	Ta
74	tungsten, (wolfram)	W
75	rhenium	Re
76	osmium	Os
77	iridium	Ir
78	platinum	Pt
79	gold, (aurum)	Au
80	mercury, (hydrargyrum)	Hg
81	thallium	Tl
82	lead, (plumbum)	Pb
83	bismuth	Bi
84	polonium	Po
85	astatine	At
86	radon	Rn

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[1] Quoted from: IUPAC, Physical Chemistry Division: Quantities, Units and Symbols in Physical Chemistry (1988). The names in parentheses are added for information.

Atomic number	Name	Symbol
87	francium	Fr
88	radium	Ra
89	actinium	Ac
90	thorium	Th
91	protactinium	Pa
92	uranium	U
93	neptunium	Np
94	plutonium	Pu
95	americium	Am
96	curium	Cm
97	berkelium	Bk
98	californium	Cf
99	einsteinium	Es
100	fermium	Fm
101	mendelevium	Md
102	nobelium	No
103	lawrencium	Lr
104	unnilquadium	Unq
105	unnilpentium	Unp
106	unnilhexium	Unh
107	unnilseptium	Uns
108	unniloctium	Uno
109	unnilennium	Une

Annex B
(normative)

Symbols for chemical elements and nuclides

Symbols for chemical elements shall be written in roman (upright) type. The symbol is not followed by a full stop.

EXAMPLES

H He C Ca

The attached subscripts or superscripts specifying a nuclide or molecule shall have the following meanings and positions.

The nucleon number (mass number) of a nuclide is shown in the left superscript position, for example

$^{14}\mathrm{N}$

The number of atoms of a nuclide in a molecule is shown in the right subscript position, for example

$^{14}\mathrm{N}_2$

The proton number (atomic number) may be indicated in the left subscript position, for example

$_{64}\mathrm{Gd}$

If necessary, a state of ionization or an excited state may be indicated in the right superscript position.

EXAMPLES

State of ionization: Na^+, PO_4^{3-} or $(\mathrm{PO}_4)^{3-}$

Electric excited state: He^* NO^*

Nuclear excited state: $^{110}\mathrm{Ag}^*$ or $^{110}\mathrm{Ag}^{\mathrm{m}}$

Annex C
(informative)

Original names and symbols for nuclides of radioactive series

(4n + 2)-series (uranium series)			4n-series (thorium series)			(4n + 3)-series (actinium series)		
Name	**Old symbol**	**Symbol of nuclide**	**Name**	**Old symbol**	**Symbol of nuclide**	**Name**	**Old symbol**	**Symbol of nuclide**
uranium I	U I	^{238}U	thorium	Th	^{232}Th	actinouranium	AcU	^{235}U
uranium X$_1$	U X$_1$	^{234}Th	mesothorium 1	MsTh$_1$	^{228}Ra	uranium Y	U Y	^{231}Th
uranium Z, uranium X$_2$	U Z, U X$_2$	^{234}Pa	mesothorium 2	MsTh$_2$	^{228}Ac	protoactinium	Pa	^{231}Pa
uranium II	U II	^{234}U	radiothorium	RdTh	^{228}Th	actinium	Ac	^{227}Ac
ionium	Io	^{230}Th	thorium X	Th X	^{224}Ra	radioactinium	RdAc	^{227}Th
radium	Ra	^{226}Ra	thoron	Tn	^{220}Rn	actinium K	Ac K	^{223}Fr
radon	Rn	^{222}Rn	thorium A	Th A	^{216}Po	actinium X	Ac X	^{223}Ra
radium A	Ra A	^{218}Po	thorium B	Th B	^{212}Pb	actinon	An	^{219}Rn
radium B	Ra B	^{214}Pb	thorium C	Th C	^{212}Bi	actinium A	Ac A	^{215}Po
radium C	Ra C	^{214}Bi	thorium C'	Th C'	^{212}Po	actinium B	Ac B	^{211}Pb
radium C'	Ra C'	^{214}Po	thorium C''	Th C''	^{208}Tl	actinium C	Ac C	^{211}Bi
radium C''	Ra C''	^{210}Tl	thorium D	Th D	^{208}Pb	actinium C'	Ac C'	^{211}Po
radium D	Ra D	^{210}Pb				actinium C''	Ac C''	^{207}Tl
radium E	Ra E	^{210}Bi				actinium D	Ac D	^{207}Pb
radium F (polonium)	Ra F	^{210}Po						
radium G	Ra G	^{206}Pb						

Annex D
(informative)

Examples of relations in different systems of equations

Item No.	Subject	Rationalized system of equations with four base quantities	Gaussian system of equations with three base quantities
1	Bohr radius	$a_0 = 4\pi\varepsilon_0\hbar^2/m_e e^2$	$a_0 = \hbar^2/m_e e_s^2$
2	Rydberg constant	$R_\infty = m_e e^4/(4\pi)^3\varepsilon_0^2\hbar^3 c$	$R_\infty = m_e e_s^4/4\pi\hbar^3 c$
3	Bohr magneton	$\mu_B = e\hbar/2m_e$	$\mu_{B,\,s} = e_s\hbar/2m_e c$
4	nuclear magneton	$\mu_N = e\hbar/2m_p$	$\mu_{N,\,s} = e_s\hbar/2m_p c$
5	relation between gyromagnetic coefficient and *g*-factor of nucleus	$\gamma = g\mu_N/\hbar = ge/2m_p$	$\gamma_s = g\mu_{N,\,s}/\hbar = ge_s/2m_p c$
6	Larmor angular frequency	$\omega_L = (e/2m_e)B$	$\omega_L = (e_s/2m_e c)B_s$
7	cyclotron angular frequency (of electron)	$\omega_c = (e/m_e)B$	$\omega_c = (e_s/m_e c)B_s$
8	fine-structure constant	$\alpha = e^2/4\pi\varepsilon_0\hbar c$	$\alpha = e_s^2/\hbar c$
9	electron radius	$r_e = e^2/4\pi\varepsilon_0 m_e c^2$	$r_e = e_s^2/m_e c^2$
10	Compton wavelength	$\lambda_C = h/mc = 2\pi\hbar/mc$	$\lambda_C = h/mc = 2\pi\hbar/mc$

Quantities occurring in the second column of equations which differ from the corresponding quantity in the first column of equations have a suffix s (symmetric). The values of some of the quantities expressed in CGS units of the Gaussian system (see the introduction to ISO 31-5:1992, subclause 0.5.2) are as follows:

$\mu_{B,\,s} = (9{,}274\ 015\ 4 \pm 0{,}000\ 003\ 1) \times 10^{-21}$ erg per gauss

$\mu_{N,\,s} = (5{,}050\ 786\ 6 \pm 0{,}000\ 001\ 7) \times 10^{-24}$ erg per gauss

$\gamma_{p,\,s} = (2{,}675\ 221\ 28 \pm 0{,}000\ 000\ 81) \times 10^4$ reciprocal second reciprocal gauss, where $\gamma_{p,\,s}$ is the Gaussian gyromagnetic coefficient γ_s of the proton.

(*Continued from second cover*)

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
ISO 31-5 : 1992	IS 1890 (Part 5) : 1995 Quantities and units : Part 5 Electricity and magnetism (*first revision*)	Identical
ISO 31-6 : 1992	IS 1890 (Part 6) : 1983* Quantities, units and symbols : Part 6 Light and related electromagnetic radiations	Technically Equivalent
ISO 31-7 : 1992	IS 1890 (Part 7) : 1995 Quantities and units : Part 7 Acoustics (*first revision*)	Identical
ISO 31-8 : 1992	IS 1890 (Part 8) : 1995 Quantities and units : Part 8 Physical chemistry and molecular physics (*first revision*)	Identical
ISO 31-9 : 1992	IS 1890 (Part 9) : 1995 Quantities and units : Part 9 Atomic and nuclear physics (*first revision*)	Identical
ISO 31-10 : 1992	IS 1890 (Part 10) : 1995 Quantities and units : Part 10 Nuclear reactions and ionizing radiation (*first revision*)	Identical
ISO 31-11 : 1992	IS 1890 (Part 11) : 1995 Quantities and units : Part 11 Mathematical signs and symbols for use in the physical science and technology (*second revision*)	Identical
ISO 31-12 : 1992	IS 1890 (Part 12) : 1995 Quantities and units: Part 12 Characteristic numbers (*first revision*)	Identical
ISO 31-13 : 1992	IS 1890 (Part 13) : 1983* Quantities, units and symbols : Part 13 Solid state physics	Technically Equivalent

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